Preparation of Alternative Fuels

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SUMMARY

Alternative fuels used in the cement manufacturing process originate from waste, which often doesn't have suitable physical properties for the kiln process. This is where alternative fuel preparation is needed.

This paper focuses on common waste treatment techniques for alternative fuel production. For a complete understanding of the subject, the lecture of the Cement Course paper "Use of Alternative Fuels" is recommended.

1. INTRODUCTION

Waste is a residual product of some sort of process. Its physical properties are characterized by this process. Alternative fuel, on the other hand, is a combustible for clinker manufacture. It must have physical properties suited for incineration in a cement kiln. In many cases the properties of waste and alternative fuel do not correspond. This is where alternative fuel preparation is required.

2. FROM WASTE TO ALTERNATIVE FUEL

2.1 Waste Properties

When waste material is considered for alternative fuel use, first of all, its **chemical composition** (circulating elements, ash composition) must be suited for the kiln process. Then there are other properties and aspects, which need to be looked at:

- The **viscosity** of liquid waste determines the design of the storage and handling installation.
- Corresponding to the **granulometry** of solid waste, a size reduction process might have to be considered and the suitable kiln feeding point is chosen.
- **Water** contained in liquids requires mixing for better homogeneity of the alternative fuel. Water contained in solid waste has an impact on the handling as it might change the flowability of the material.
- **Foreign bodies and impurities** need to be separated in order to reduce wear and the risk of blockages.
- **Safety** is very important when dealing with waste, e.g. **toxicity** and **flashpoint** need to be considered.
- Additional aspects refer to the waste supply, such as **annual tonnage** as well as **form and schedule of delivery**.

2.2 Processing of Waste

As for any other process, for the preparation of alternative fuel the most simple and inexpensive but also safe process is suited best. A mechanical waste treatment is therefore chosen in almost any case.

Similar to the mechanical processes in cement manufacture the preparation of alternative fuel comprises of the following main processes:

- **Screening** to separate foreign and oversized material which might cause handling or wear problems in fuel preparation and firing installations.
- **Size reduction** to fit the fuel to the foreseen firing point (e.g. preheater, main burner), as well as to allow a proper dosing and to ensure a good combustion.
- **Homogenizing and mixing** to feed to the kiln process a fuel of constant quality.

Picture 1 gives and overview of the different processes from waste to alternative fuel. Explanation is given in the following chapters.

Picture 1: Processes from waste to alternative fuel

Thermal waste processing (gasification/pyrolysis) is applied in a few cement plants. It is operated in conjunction with the kiln. Gasification allows separating the combustible fraction of a waste in a gaseous form from the non-combustible part. The investment cost for such installation is comparably high, which makes this process worthwhile only when considerable disposal fees are received.

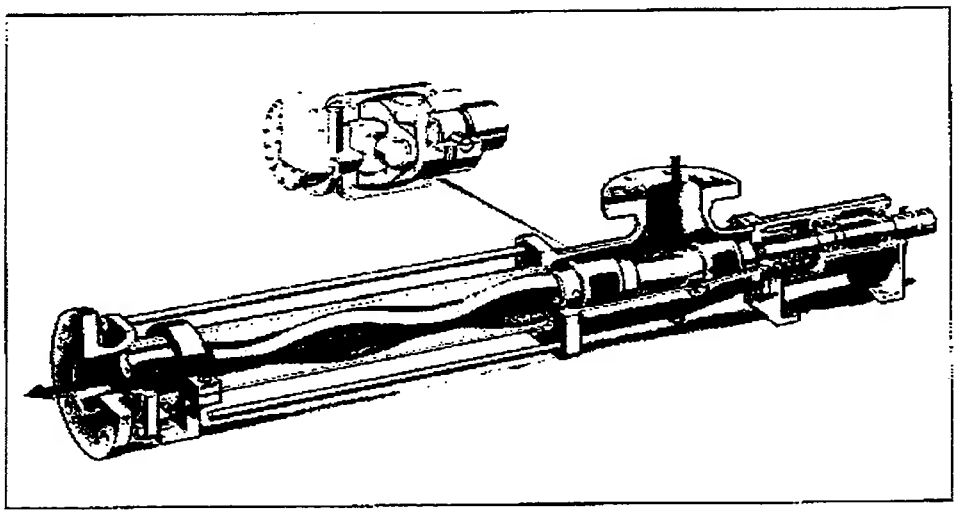
3. LIQUID ALTERNATIVE FUEL PREPARATION

In many cement plants, liquid waste has been the first waste material to be accepted and used as alternative fuel because little preparation is necessary and, in certain cases, existing installations may be used. However, there are special aspects that need to be considered when handling liquid waste such as waste oil and solvents.

3.1 Pollution of Liquid Waste

Liquid waste is likely to be polluted with foreign bodies (metal pieces, sand, plastics etc.). A coarse filtering upon reception is therefore necessary. With in-line shredders and grinders remaining particles can be crushed to avoid blockages. Even after a second filter in the kiln firing line, there are still solid particles present in the liquid. The pumping and kiln injection system must therefore be designed accordingly.

Picture 2: Screw pole pump, suited for waste oil containing solid particles



3.2 Homogenizing

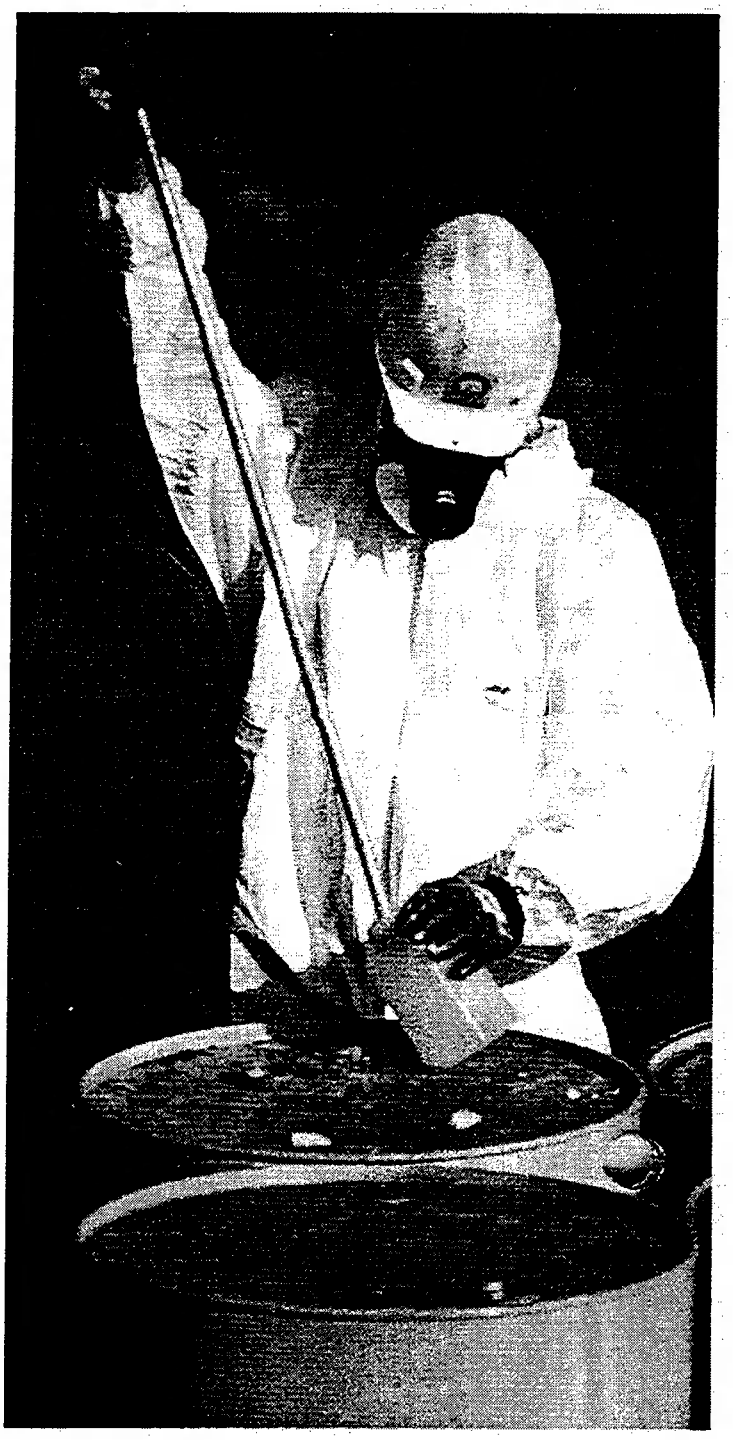
Due to the presence of solids and often also mixtures of liquids with different densities, a mixing tank is required. A recirculation circuit or mechanical mixer ensures a good blending.

3.3 Safety

The handling of solvents or liquid waste containing solvents represents a safety risk since there is a high potential for explosion. The decisive parameter for the safe design of a liquid installation is the liquid's flashpoint (the flashpoint is the temperature at which the evaporations of a combustible liquid form an inflammable gas). Pure motor oil has a flashpoint of up to 200°C whereas other liquids, such as solvents, can have one below 0°C.

Another safety risk to workers and the environment represent toxic substances. Special protection and safety procedures are required. The guideline for this should always be the safety standards applied in the chemical industry.

Picture 3: Protected worker sampling liquid waste



4. PREPARATION OF ALTERNATIVE FUEL FROM PASTY WASTE

In industrial areas there are often considerable amounts of pasty or sludgy waste materials available, such as

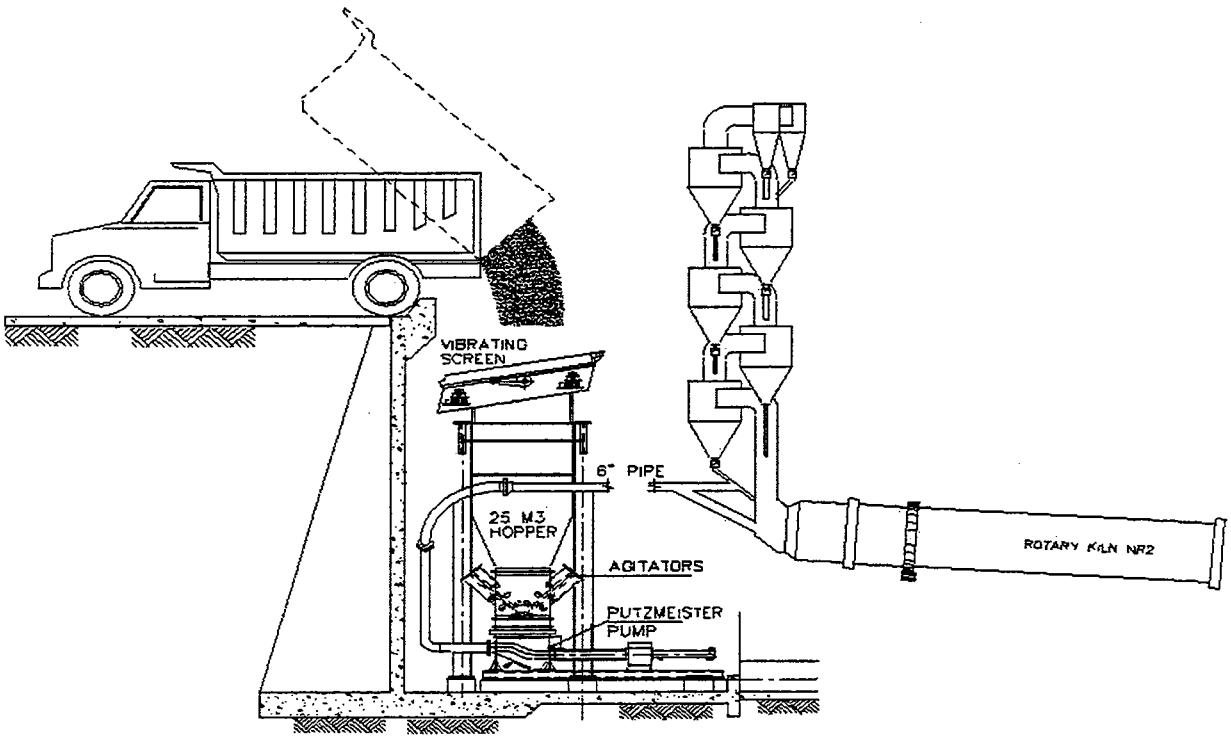
- resin, paint, varnish
- oil sludges from tank cleaning
- destillation residues
- grease, soap.

Many of these materials are hazardous. With regard to the variable clinker production cost, they can therefore be of particular interest as considerable disposal fees may be received.

From the point of view of incineration, it is important that such waste is burnt at high temperatures with sufficient residence time (The combustion criteria for destruction of halogenated waste for example is 1'200 °C with 2 seconds residence time). This is only ensured at the main burner of a cement kiln. Therefore, the hazardous, pasty waste must be pre-treated for incineration in the primary firing.

There are two common ways of sludge pre-treatment for incineration in the primary firing, see below. For mainly non-hazardous sludges there is the possibility of kiln inlet feeding. With such application, the sludge is screened to take out coarse foreign bodies before being pumped to the kiln by means of a concrete pump. Sludge feeding at the kiln inlet is limited due to the high water input.

Picture 4: Sludge feeding installation to kiln inlet (Apaxco plant)



4.1 High Viscosity Liquid Facility

A so-called high viscosity liquid facility aims to liquefy the sludgy waste. This is achieved by mixing the sludge with liquid fuel. The important aspect of this process is the compatibility of the substances involved. To avoid chemical reaction, sludge and liquid need to fulfill certain requirements. This however, limits the use of such pre-treatment system to certain substances, which is a drawback with regard to flexibility.

4.2 Impregnation Facility

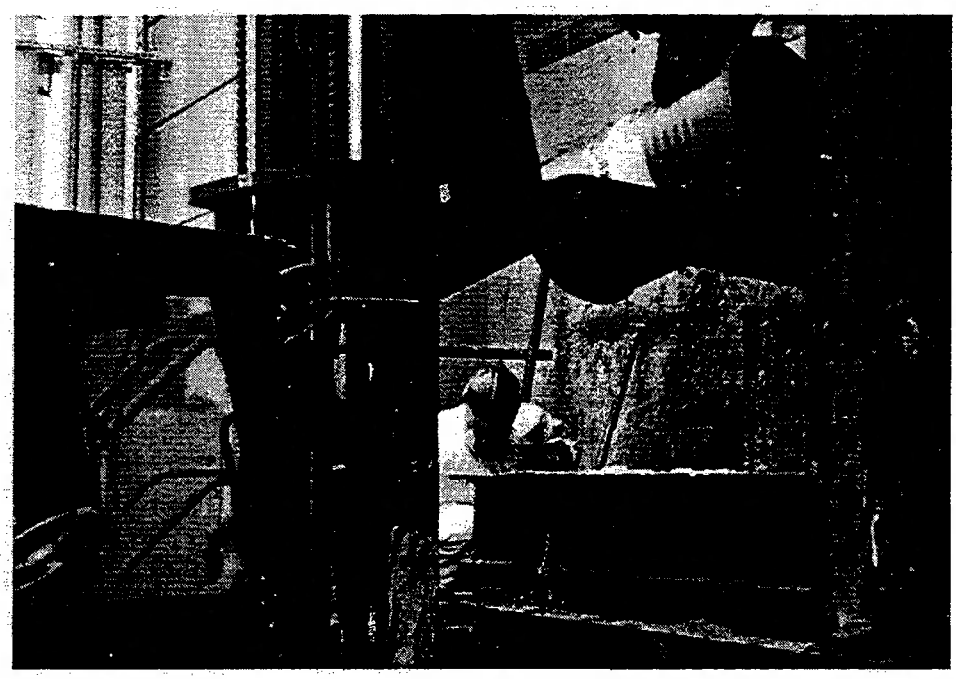
The other common sludge pre-treatment process aims to prepare a pourable, fine, solid alternative fuel. This is achieved by mixing the sludges with an impregnation support. Saw dust is commonly used for this purpose. It has a good absorbency and the impregnated product shows little stickiness. Alternatively, filter cakes and also animal meal have been used as impregnation aid.

In what follows the different steps of an impregnation facility are explained.

4.2.1 Reception and Preparation of Primary Materials

The sludgy waste is delivered either in bulk or small containers (typically 200 l steel drums) and emptied into pits. There are drums, which cannot be emptied by gravity or reasonable manual effort. For such containers a robust shredding facility is needed.

Picture 5: Drum emptying



According to chemical analysis of the incoming waste and the product requirements, the unloaded materials are mixed and then shredded. The prepared mix is conveyed to a mixing station by means of a high pressure pump.

For an optimum product quality and minimum use of impregnation aid the viscosity of the batch mix is adjusted. If necessary, liquid phases are extracted from the drums or added to the mixing pit.

4.2.2 Production of Impregnated Alternative Fuel and Dispatch

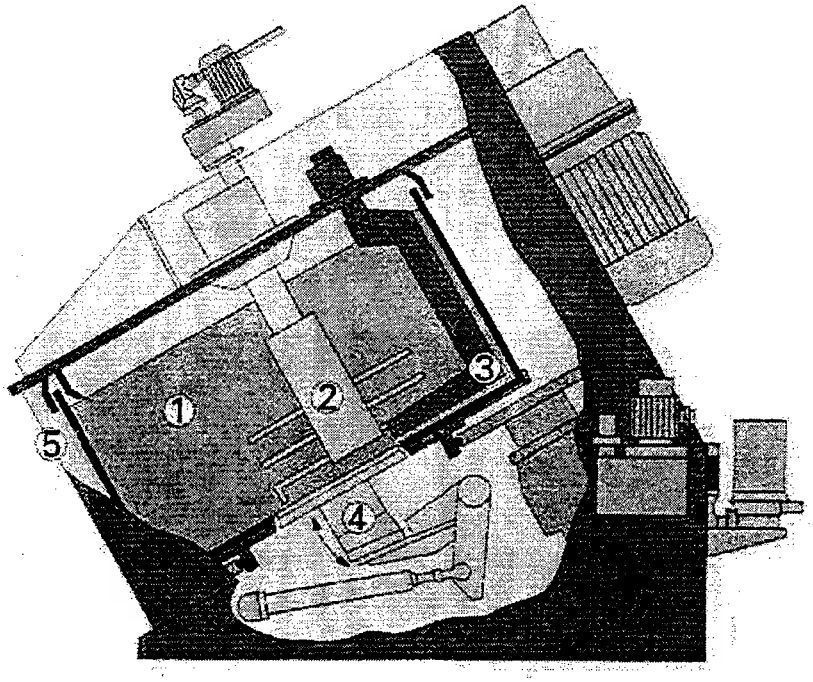
Once there is a batch of sludge prepared it needs to be mixed with sawdust. The mixing ratio is about one third of saw dust and two thirds of sludge.

For a simple installation, it is possible to mix the components by means of a wheel loader. The more sophisticated process is to use a continuously operated intensive mixer.

Legend:

1: mixing container
2: mixing tool
3: material guiding arm
4: discharge opening
5: housing

Picture 6: Intensive mixer (type Eirich)



Before storage, metals are separated and the product is screened in a drum screen. The product is fine (mostly – 10 mm) and well suited for incineration at the main firing.

For storage moving floor type silos are best suited.

4.2.3 Organic Emission

Due to the handling of unconfined chemicals there is a lot of organic emission. This requires an appropriate protection of the workforce on the one hand. On the other hand, an aspiration and thermal treatment of the emission might be necessary.

5. SOLID ALTERNATIVE FUEL PREPARATION

Solid waste can be fed in a coarse form to the kiln (e.g. whole tyres) but often needs to have a finer granulometry. A size reduction is necessary and determined mainly by the following process factors:

- transportation cost
- handling properties
- kiln feeding point
- thermal substitution rate
- kiln behavior.

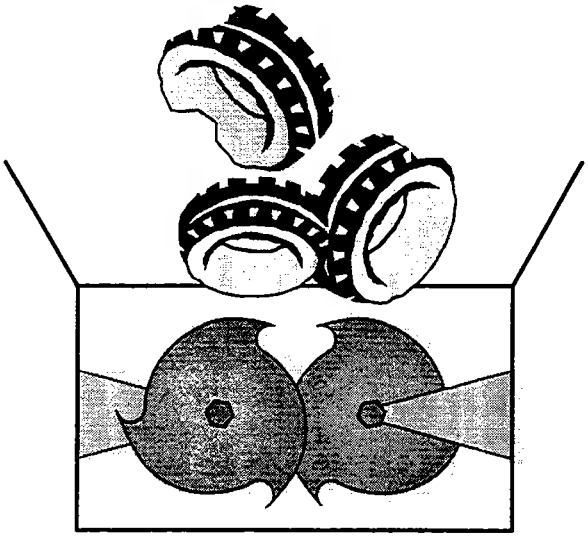
The mechanical processes used for the size reduction of solid waste are shredding and granulation. They are typically applied for materials such as wood, rubber, plastics or waste tyres.

5.1 Shredding and Granulation of Solid Waste

5.1.1 Shredders

A shredder is a machine for primary size reduction of solid materials. Its operating principle is based on a tearing and shearing action of slowly rotating tools (10 – 40 rpm) agitated by a high torque drive.

Picture 7: Typical shredder design with two counterrotating shafts



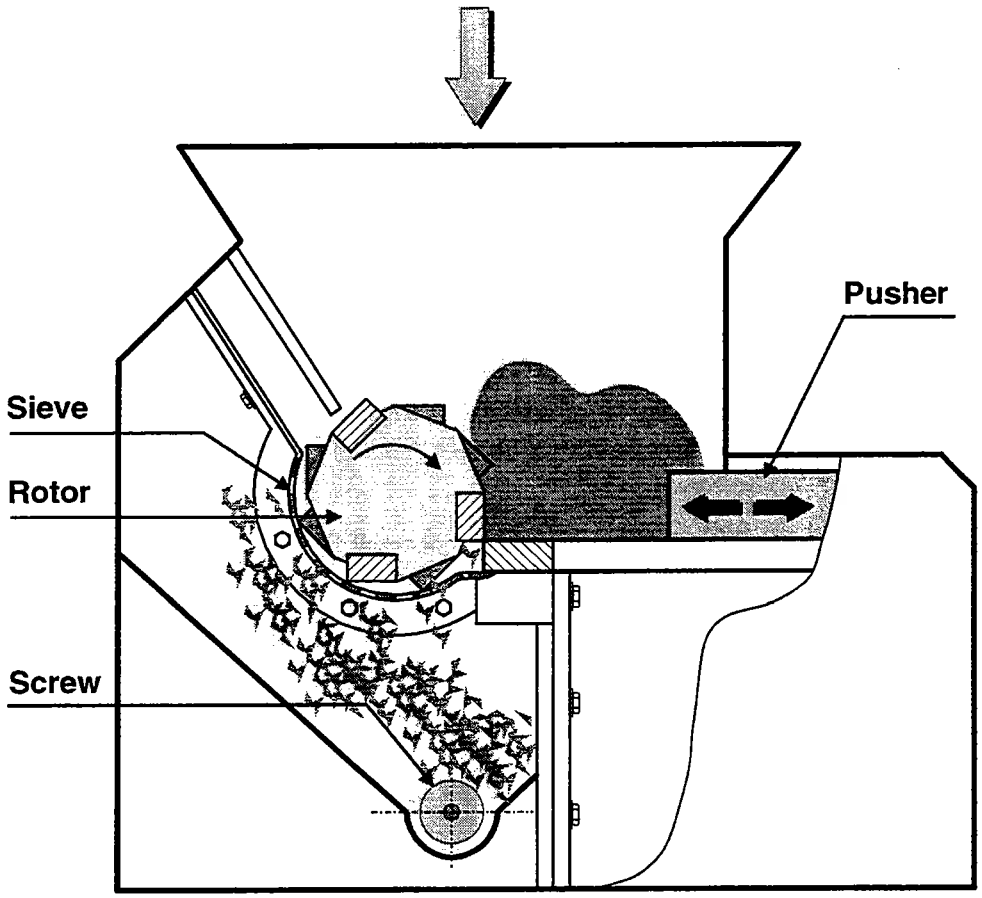
Typically, a shredder consists of two counterrotating shafts. On these shafts engaging disks with hook type knives are mounted to grab and tear the material fed. Such shredder is preferably used for the size reduction of high-density waste (e.g. wood and tyres). Waste materials with a low bulk density such as plastic films require a shredder with large feed opening and a mechanism to push the material towards the cutting rotor. For such application single rotor shredders are used.

Depending on the knife size and operation (multiple stage, closed circuit) a minimum chip size of 20 – 50 mm can be achieved.

5.1.2 Granulators

Granulators (also called grinders) are generally used for secondary size reduction. The typical design consists of a single rotor with a fixed counter knife and an outlet sieve. There is a mechanism to push waste material towards the rotor where knives grab it. After being cut at the fixed counter knife the waste chips are further milled before they pass the outlet sieve. A granulator operates at higher rpm than a shredder, above about 100 rpm.

Picture 8: Typical granulator design with one shaft and outlet sieve



Due to their high rotor speed, granulators are used for low abrasive material. Waste containing considerable amounts of metals and/or mineral material should not be granulated because of excessive wear. The spacing between the rotor knife and the fixed counter knife needs to be small (about 0.5 mm) to efficiently cut fine material like plastic films.

5.1.3 Multi-Stage Size Reduction

For the firing of waste materials at the preheater/precalciner, a single stage size reduction is sufficient in most cases. If bulky waste material is to be fired at the main burner a multiple stage shredding and granulation is required for the efficient production of an alternative fuel of a few millimeter size.

6. EXAMPLES

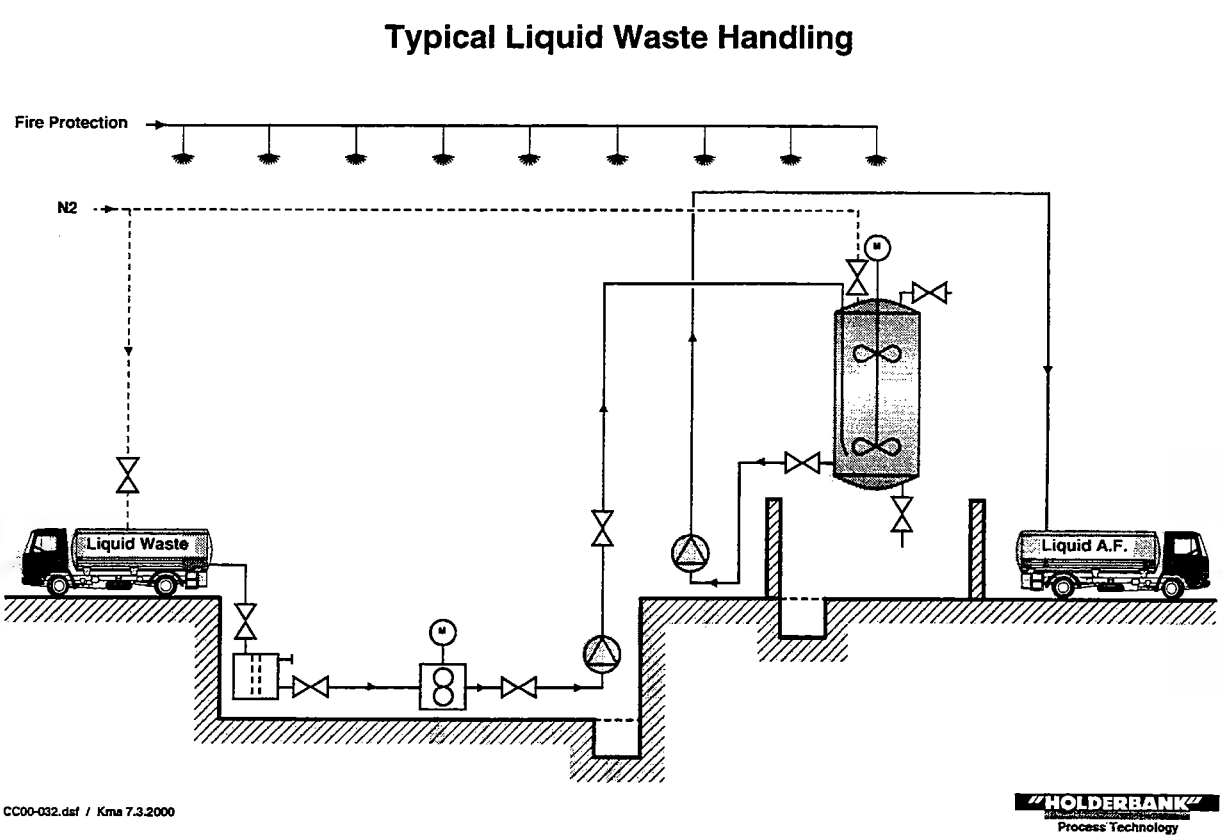
6.1 Typical Liquid Waste Handling

A typical handling facility for the reception of liquid waste and the production of liquid alternative fuel is shown in picture 9.

The installation consists of the following main elements:

- Liquid waste decanting tank with primary filtration
- Shredder to crush oversized particles for protection of the pump and to avoid blockages.
- Discharge pump, typically of centrifugal type
- Liquid storage tank with mechanical mixer
- Loading pump, typically of centrifugal type
- In case of low flashpoint liquid, a nitrogen inertisation system
- Sprinkling system for fire suppression

Picture 9: Typical liquid waste handling installation



6.2 SCORIBEL Impregnated Sawdust Production

SCORIBEL is a Belgium based subsidiary of Ciments d'Obourg. At the impregnation workshop of its Seneffe plant solid, pasty and liquid waste is mixed with an impregnation aid to form a fine, solid alternative fuel for incineration at the main firing of cement kilns.

The installation consists of three main parts:

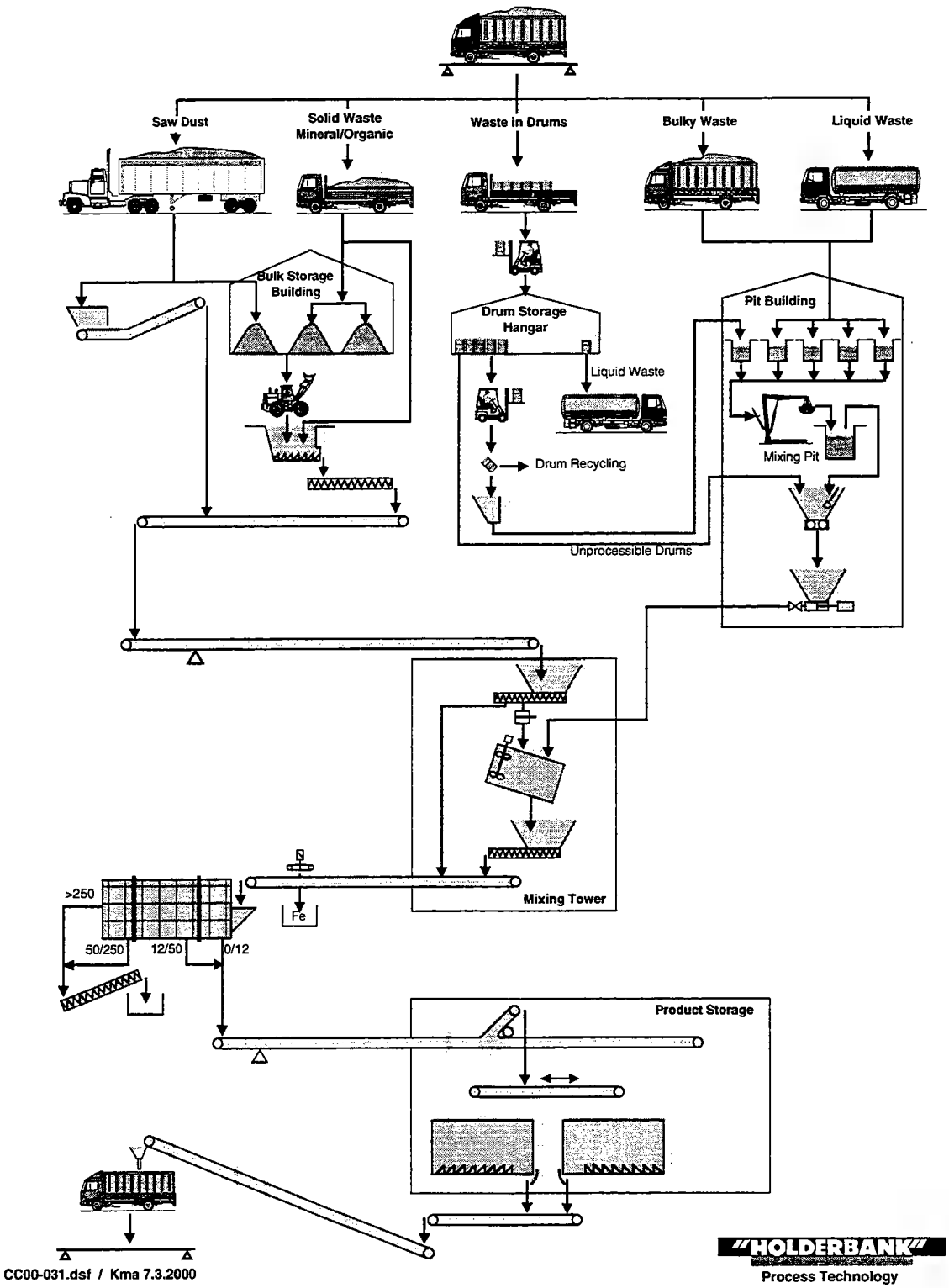
- A reception section for industrial waste in bulk or containers as well as the impregnation aids sawdust and filter cake. In a closed building the liquid, pasty and solid waste is premixed and shredded.
- By means of a continuously operated intensive mixer the waste sludge is mixed with the impregnation aid before being screened.
- In two moving floor type silos the product is stored and homogenized before being loaded to trucks.

For reduction of organic emission air is aspirated at the main sources of emission and sent to a thermal treatment unit.

The plant's design production capacity is 15 t/h, actually it is operated at more than 20 t/h.

Investment cost for the impregnation facility (excl. air treatment): BEF 250 Mio.

Picture 10: flowsheet of SCORIBEL's impregnation workshop



6.3 Industrial Plastic Waste Shredding at PLASTREC AG

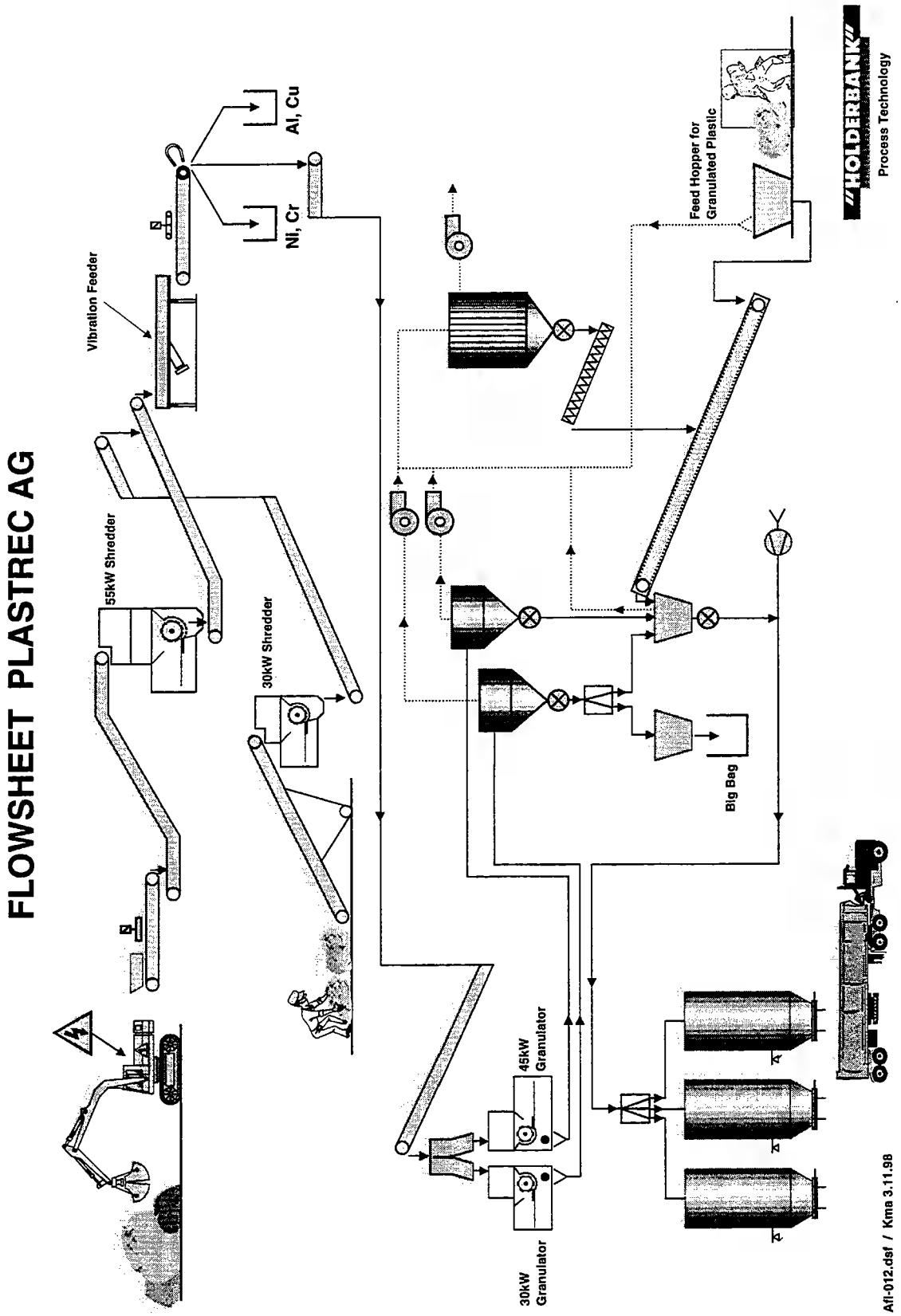
PLASTREC AG, a subsidiary of HCB, operates a facility for the shredding of industrial plastic and rubber waste to a product for use at the primary firing of cement kilns. The waste materials received are cables, textile reinforced plastic, residues from manufacture of hard plastic items, plastic films and rubber.

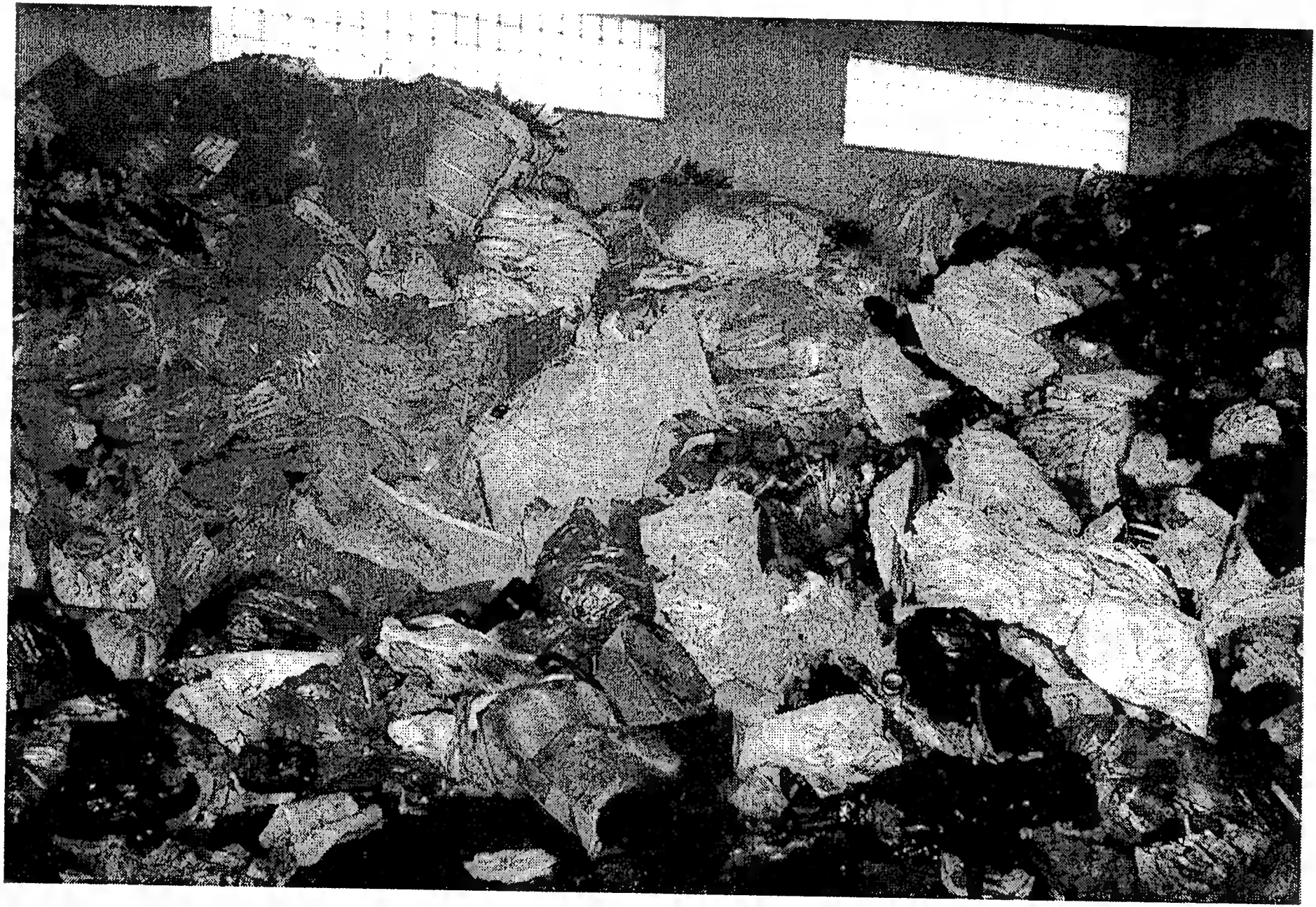
The facility is designed to mechanically process the incoming waste to a product of 10 mm size. This is achieved by pre-shredding and subsequent grinding of the material. Two shredders and two granulators, each operated in parallel, are used for the two-stage process. Material transport is done by belt conveyors for raw and pre-shredded material, and pneumatically for the finished product.

The plant has an hourly production rate of 1.5 – 2.0 t. The annual production is about 5'000 t. The consumption of electrical energy is 100 kWh/t for the whole facility.

Investment cost for whole installation: CHF 1.2 Mio.

Picture 11: flowsheet of PLASTREC plastic shredding plant



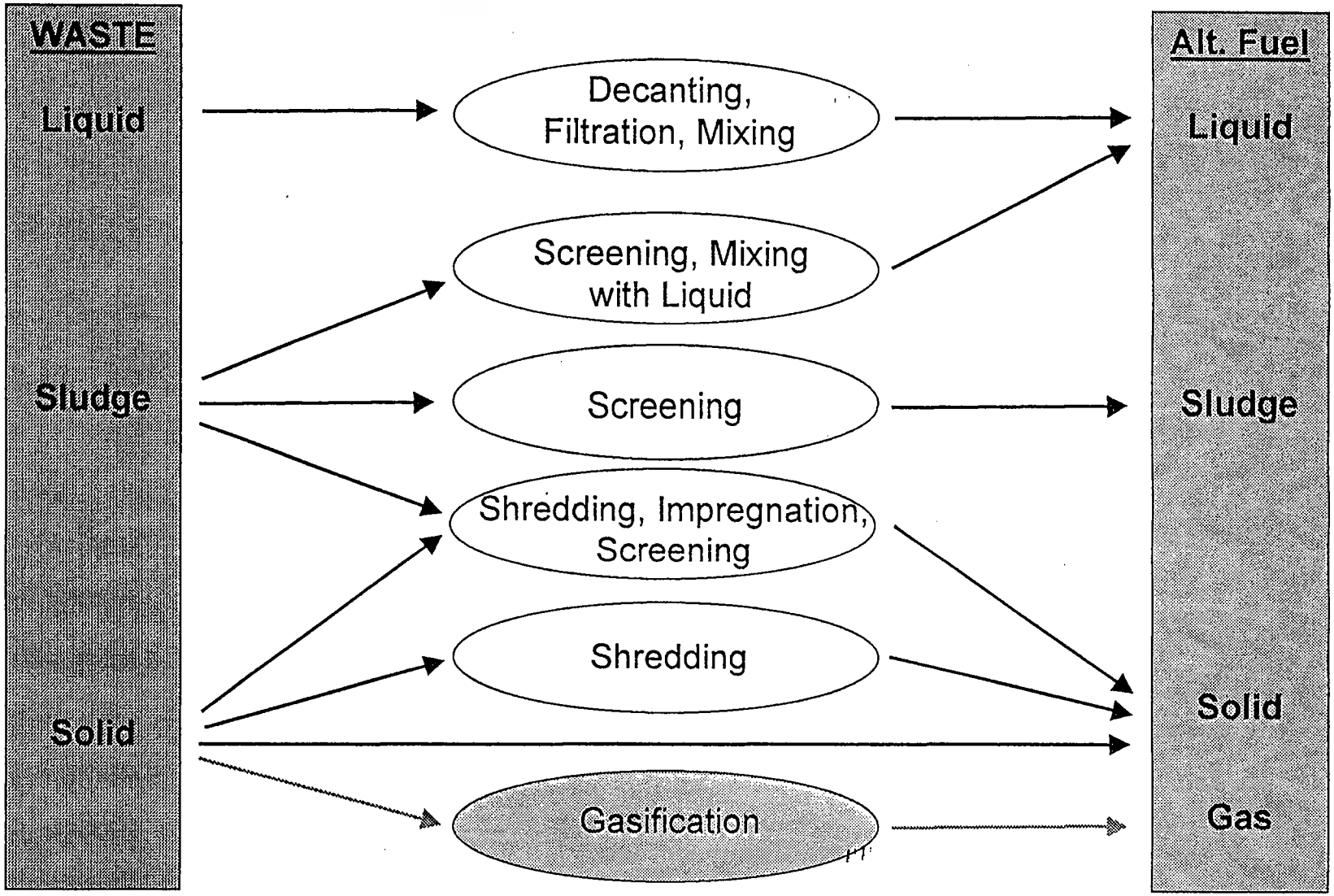


Physical Waste Properties

Alternative Fuel preparation is required to change the waste's physical properties.

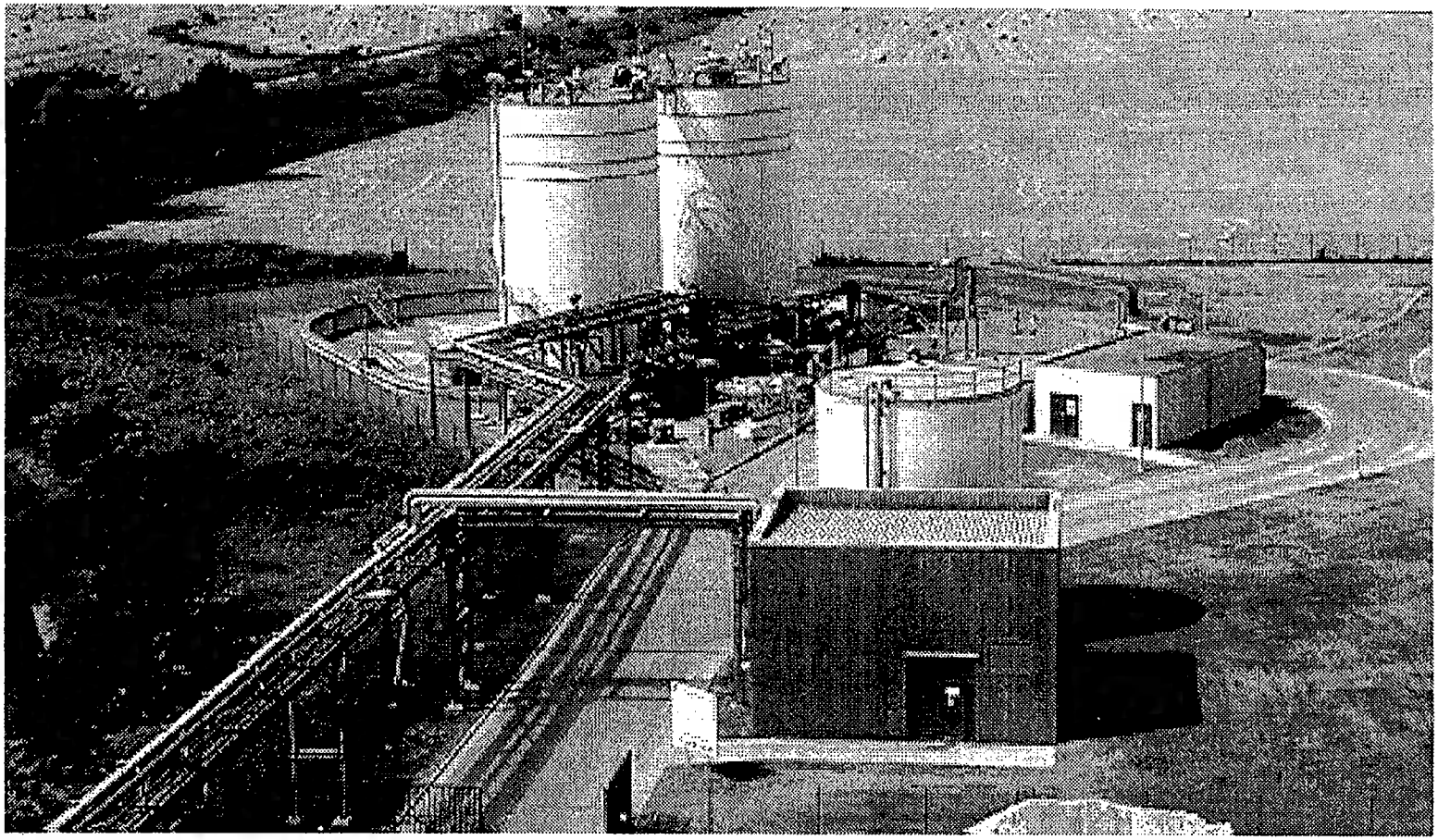
- Granulometry (Size)
- Foreign Bodies/Substances
- Water Content
- Non-Homogeneity
- Viscosity

From Waste to Alternative Fuel



Liquid Waste

Waste Oil - Solvents - Waste Water



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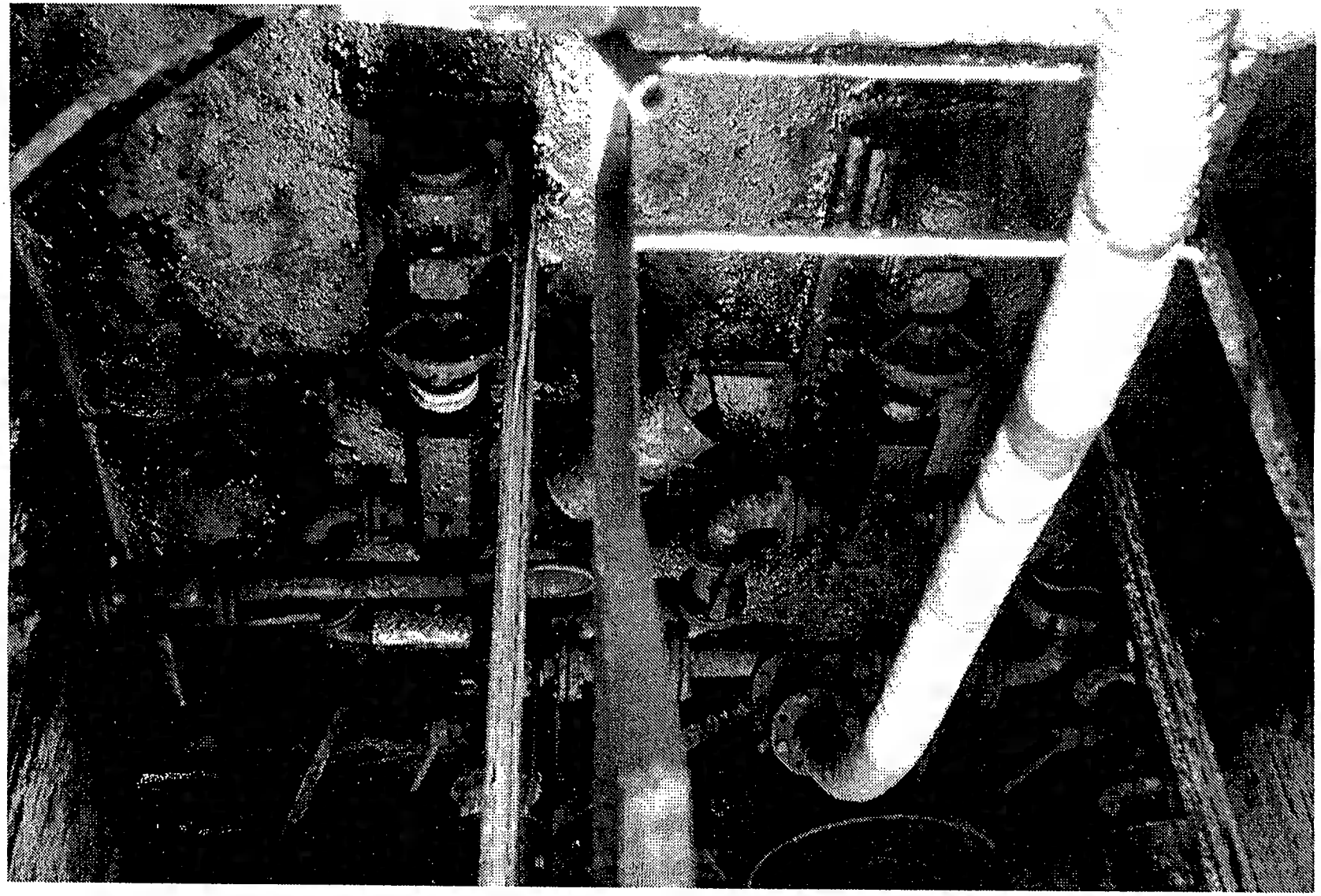
Liquid Waste - Handling Aspects

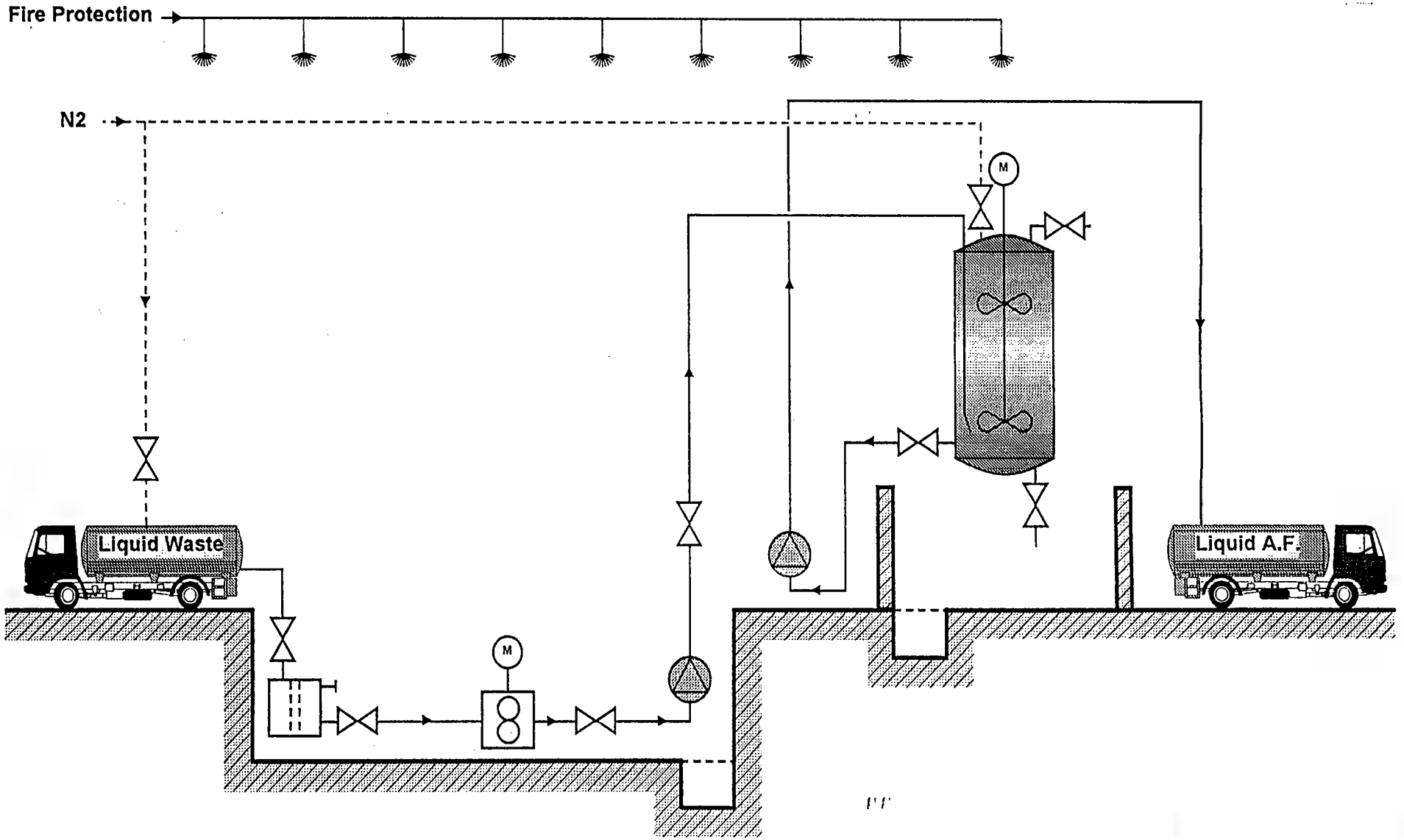
Liquid waste can be...

- polluted with solids (metals, minerals, plastics, ...)
  - decanting, filtering, grinding
  - proper selection of pump
- inhomogeneous
  - mixer, tank recirculation
- hazardous
  - protection of personnel
  - safety of installation

Flashpoint: temperature at which the evaporations of a combustible liquid form an inflammable gas.



Typical Liquid Waste Handling



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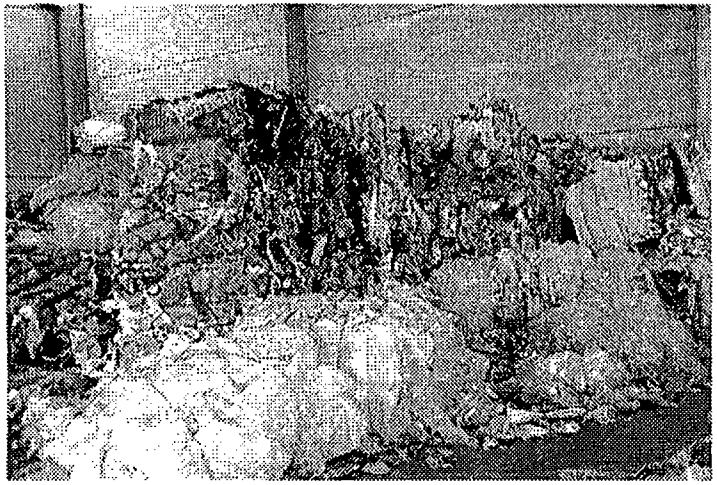
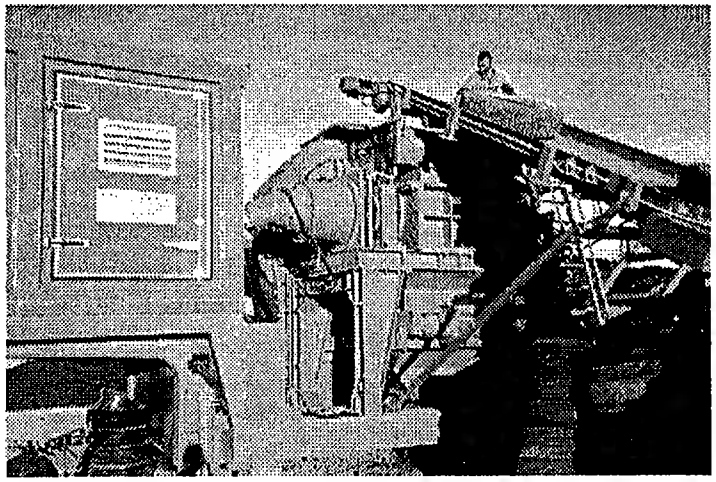
Process Technology

Liquid Waste - Safety

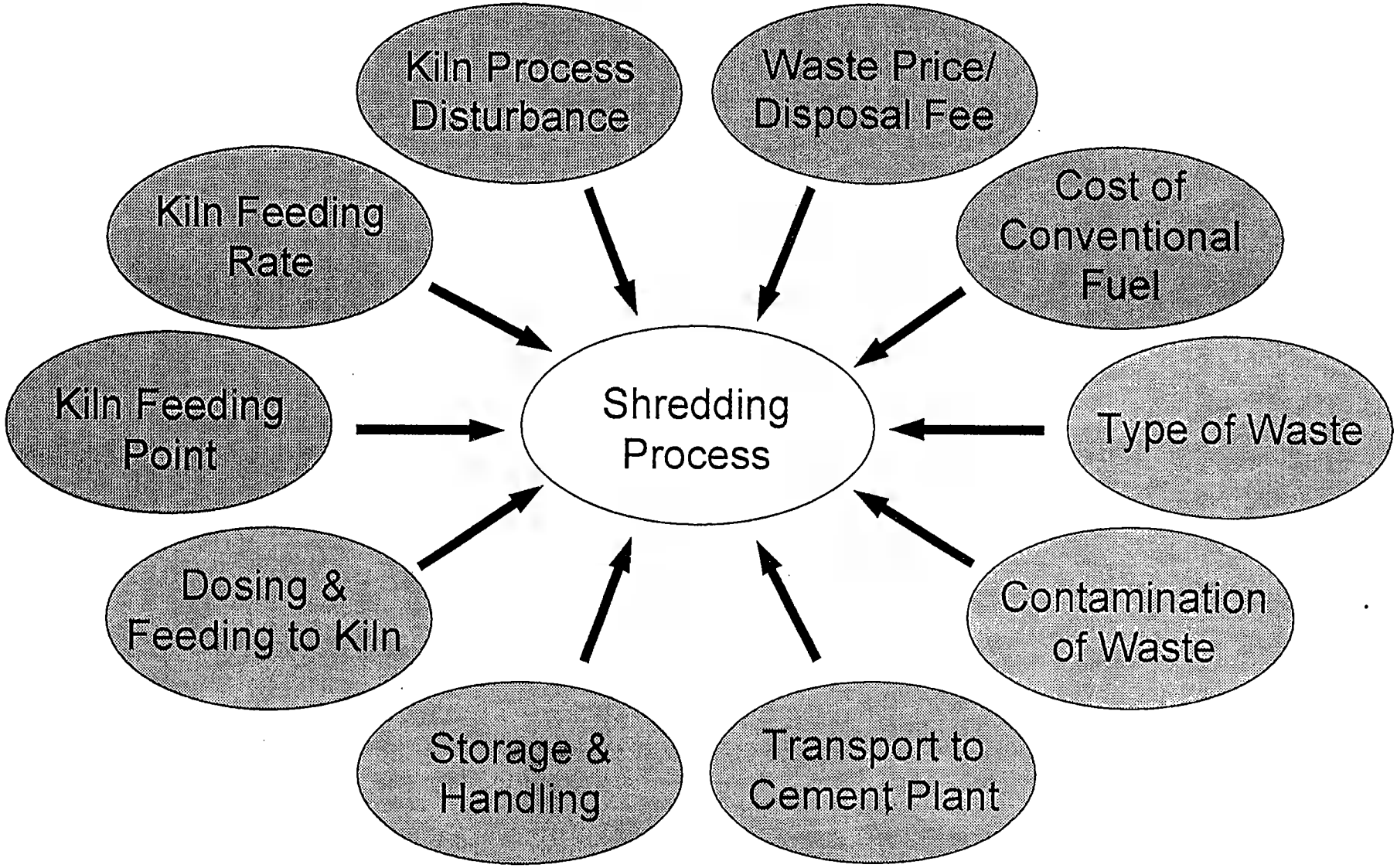
- Safety of installation:
  - Design of mechanical & electrical installation according explosion risk
  - Inertisation & explosion suppression (N_2, CO_2, ...)
  - Fire fighting facility (detectors, water/foam supply, sprinkling installation, fire fighting water basin)
- Protection of personnel:
  - Education, Instruction
  - Physical protection (overall, boots, gloves, masks with active carbon filter)

Waste Shredding



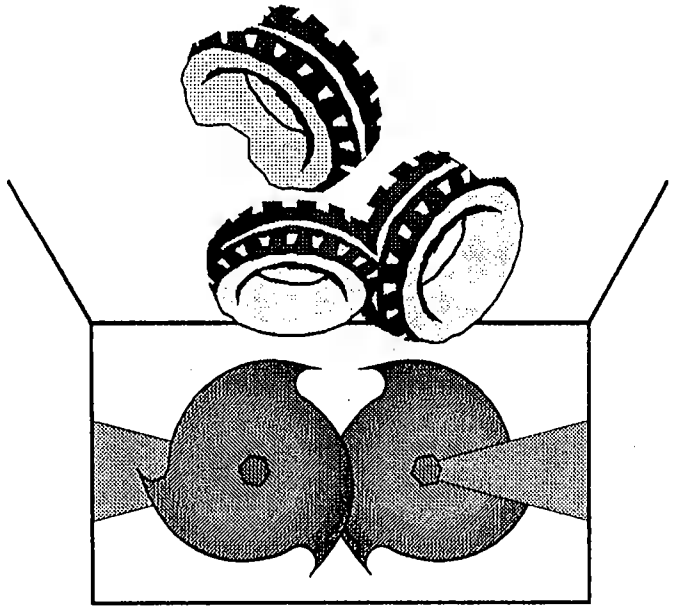


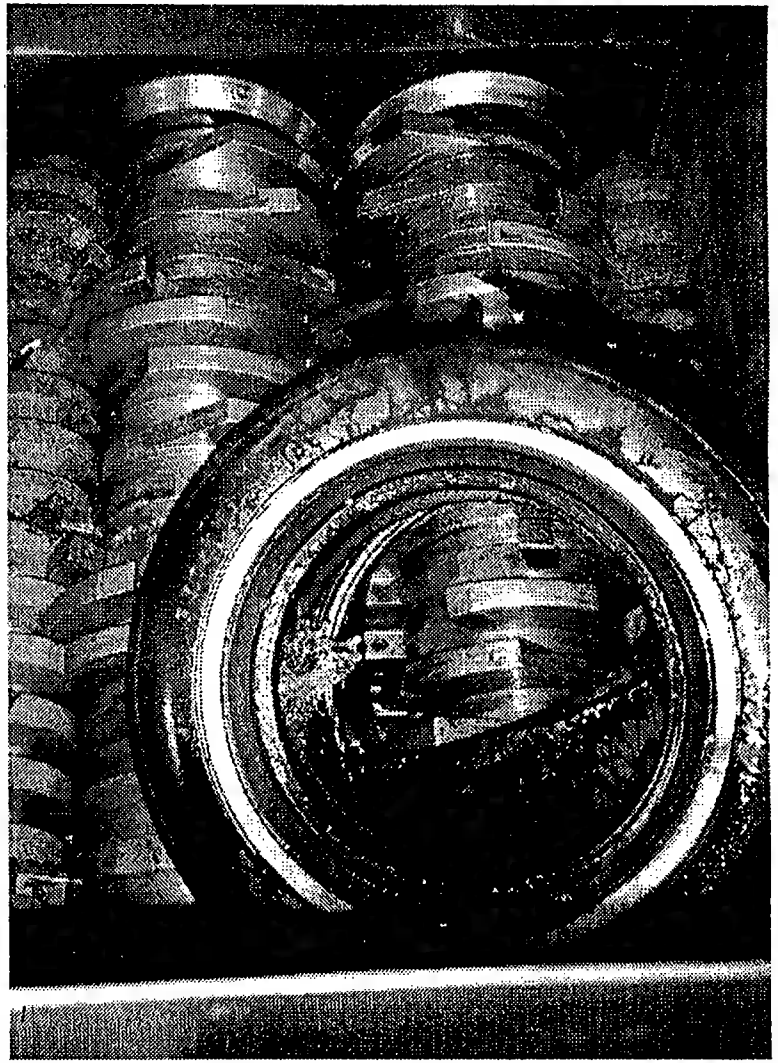
Waste Shredding - Selection Criteria



Coarse Shredder

- robust design
- low rpm drive (< 40 rpm)
- high torque drive (electric or hydraulic)
- typically two shafts





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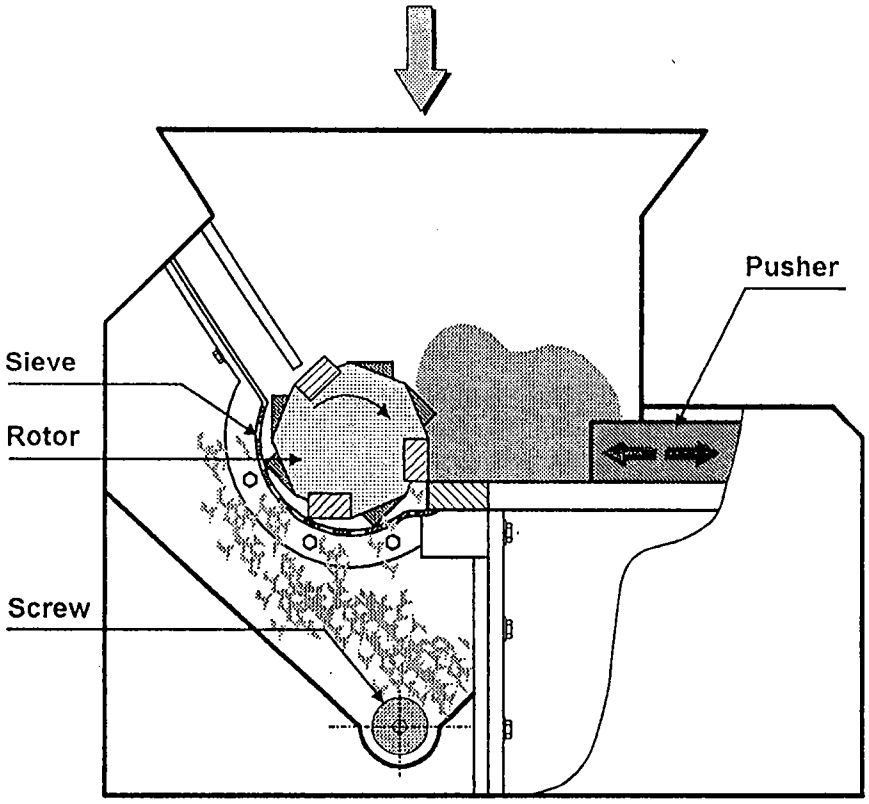
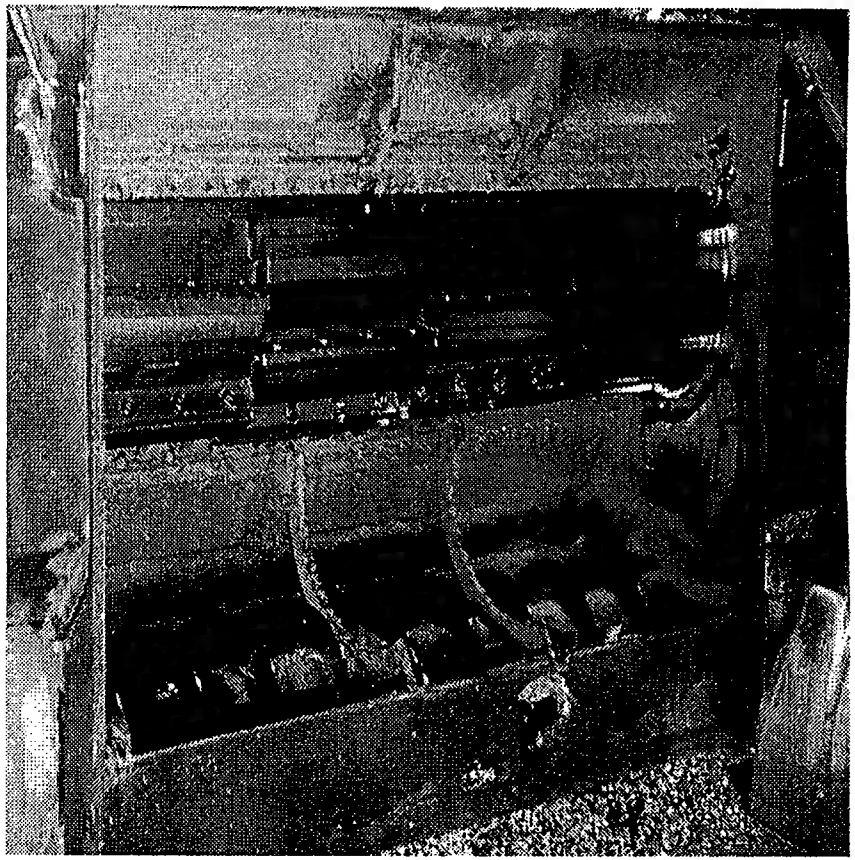
Fine Shredder

- secondary size reduction
- high rpm drive (> 100 rpm)
- sensitive to foreign bodies and abrasive material



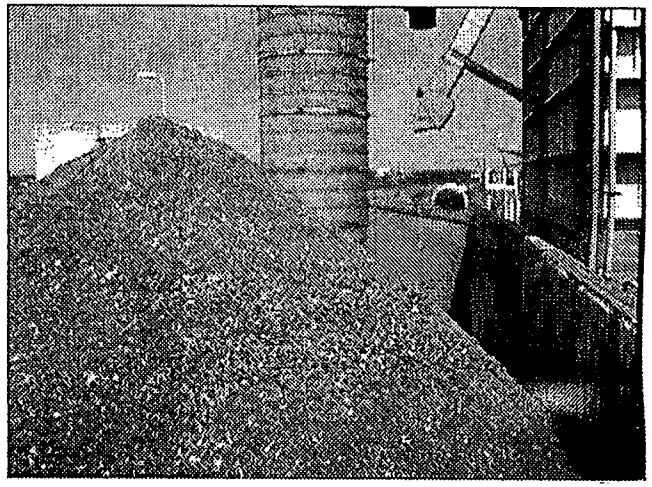


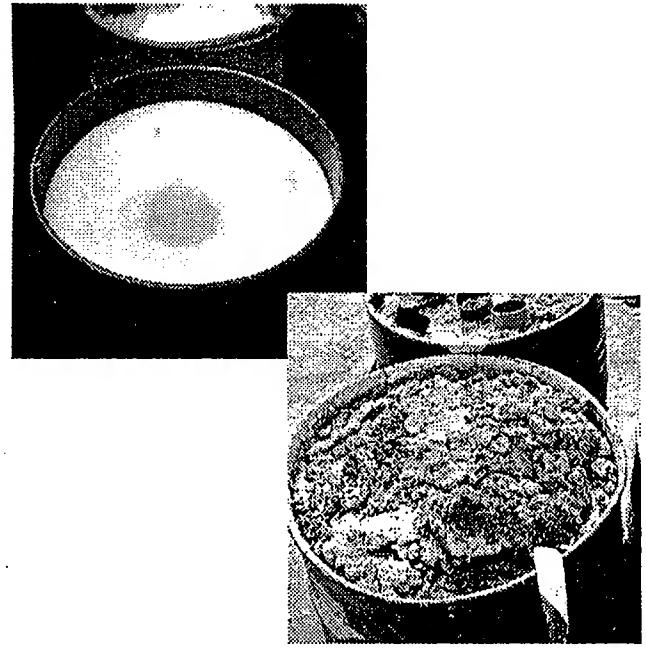
Coarse & Fine Waste Shredding

	Coarse shredding	Fine shredding
Kiln firing point	PH/PC (main burner)	main burner
Suited waste	tyres, plastics, wood, drums, ...	clean plastics, low abrasive material
Process	single stage	multiple stage
Chip size	< 150 mm	films < 30 mm granules < 5 mm
Contamination, Foreign bodies	visual check usually sufficient	metal separation, low mineral content
Power consumption	≈ 40 kWh/t (tyre)	≈ 100 kWh/t (plastic)
Operating cost	30 – 50 USD/t	depending on contamination
Versatility for other waste	yes	no

Sludge Treatment - Impregnation

Production of fine solid alt. fuel from pasty/solid waste and impregnation aid





by means of:
- sludge premixing
- coarse shredding
- impregnation
- screening
- homogenisation

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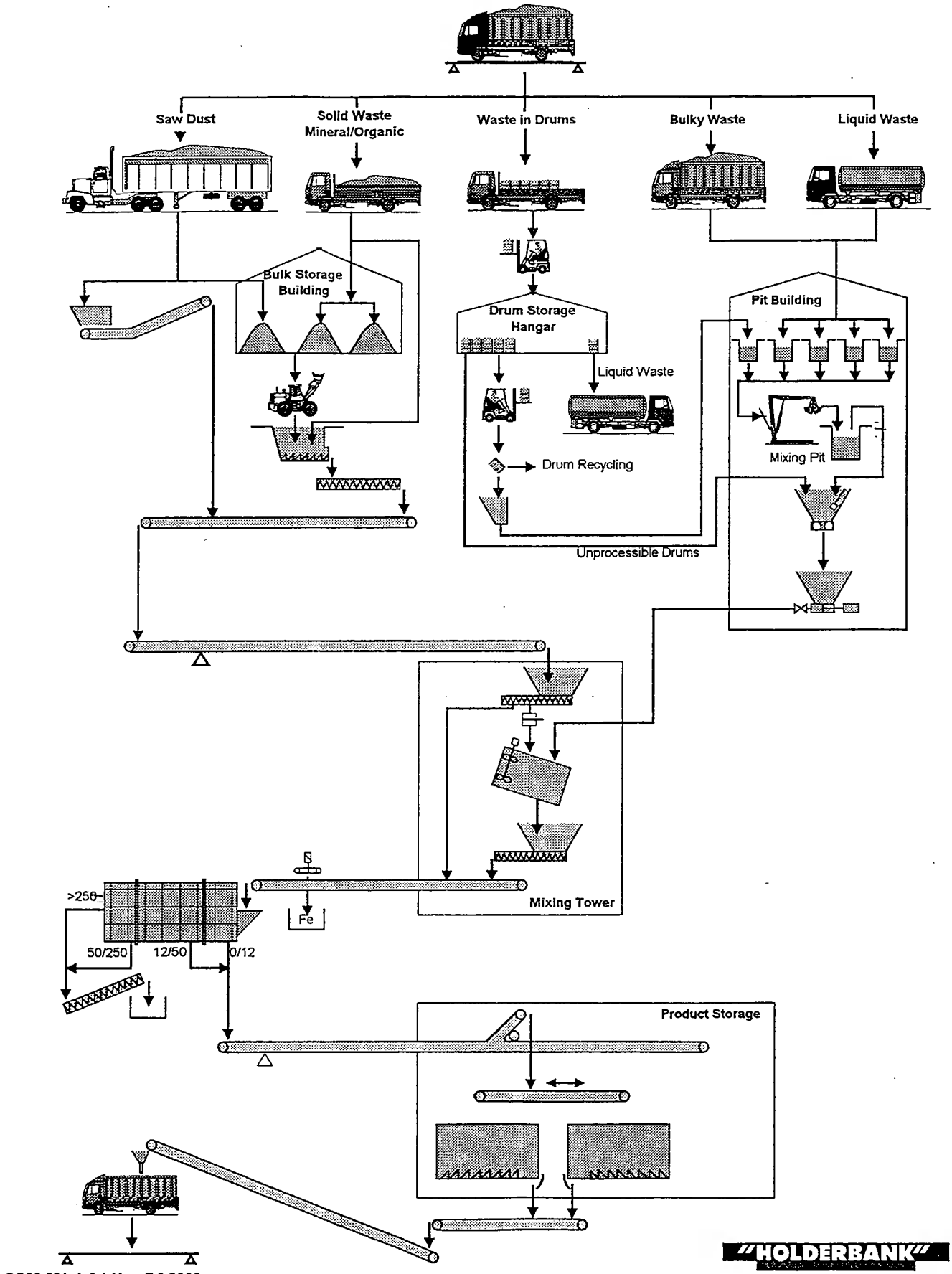
Impregnation Platform - SCORIBEL S.A. (1)

Features of SCORIBEL Impregnation Platform

- **Input materials**
  - contaminated earth, resin/paint, sludges of ink glue varnish oil, soap, ...
  - impregnation aid: sawdust, filter cake, animal meal
  - not accepted are: explosives, radioactive material, pathological substances, pharmaceutical waste, materials exceeding toxical limits
- **Products**
  - fine, solid AFR for main burner firing
    size: <12 mm of which 80% < 5mm
    density: 0.4 - 0.6 t/m^3
    PCI: ± 10.5 MJ/kg
- **Quality control of incoming waste and product**
  - incl. heavy metal and halogen analysis

SCORIBEL - Impregnated Saw Dust Production



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